A NEW SERIES OF SEDIMENT COLLECTORS FOR MONITORING TRUE BEDLOAD

Steve Miller / CH2M Hill

Dave Braatz / Streamside Systems, LLC.

http:// www.streamsidesystems.com

OUTLINE

- Overview of Sediment Transport: modes, variability, scale, and sampling bias.
- Bedload Sampling: a new method of sediment collection to avoid or minimize biases of older methods.
- Reasons for Monitoring Bedload, and the potential for developing bedload data while restoring sediment-impacted habitats.

Fluvial Sediment

- “Particles derived from rocks, biological materials, or chemical precipitants, that are transported by, suspended in, or deposited by flowing water” (USGS; ASTM)
- Bedload versus suspended ... One size of sampler does not fill all needs; 40,000 ton boulder moved 5 km in one storm.
- Scale: 13 major rivers move approximately 6 billion tons of sediment annually.

Variations in Transport:

- Vertically within water column
- Laterally across stream
- Longitudinally within basin
- Temporal, with discharge per event
- Temporal, between events (long-term)
- With instream impacts or disturbance
- With deposition on floodplain or in stream
- With new overland sources or effective controls

Subsampling = Variability

30-second sample	=	0.01 (hour);
30-sec sample	=	0.0003 (day)
30-sec sample	=	0.000001 (year)
3-inch sample	=	0.01 (20-ft w)
3-inch sample	=	0.003 (100-ft w)
(0.01)(0.01)	=	0.0001 (10,000X)
(0.000001)(0.003)	=	0.000000003

Bias of Bedload Samples from Including Suspended Sediment

- **3" X 3 " Helley-Smith**
  - **100-ft wide stream**
    - **3 fps velocity**
  - **30-second samples**

400	Samples / X-section	
2250	cubic feet / X-section	= 5.63 cubic feet / sample
63,720	liters / X-section	= 159 liters / sample

Bias of Bedload Samples from Including Suspended Sediment

- **3” X 3 “ Helley-Smith**
  - **100-ft wide stream**
    - **3 fps velocity**
  - **30-second samples**

TSS	Suspended Sediment Collected	
10 mg/L	0.637 kg	1.4 lbs
500 mg/L	31.85 kg	70.2 lbs
5000 mg/L	318.5 kg	702 lbs

Bias of Bedload Samples from Including Suspended Sediment

- **3” X 3 “ Helley-Smith**
- **100-ft wide stream**
- **3 fps velocity**
- **2-minute samples**

TSS	Suspended Sediment Collected			
10 mg/L	2.55	kg	5.6	lbs
500 mg/L	127	kg	281	lbs
5000 mg/L	1274	kg	2808	lbs

Sampling Bedload Transport

- Helley-Smith Sampler; Arnhem Sampler;
- Net-frame traps; electronic devices; acoustic;
- Birkbeck Design; Yangtze Samplers; tracers;
- Pit Traps (reduce temporal & spatial var.);
- Contour Mapping (lake storage; deltas);
- Vortex-tube bedload trap; Toutle River Sampler
- Radio transmitters; tagged particles;
- Delft Nile Sampler; Pan-type Samplers; ...

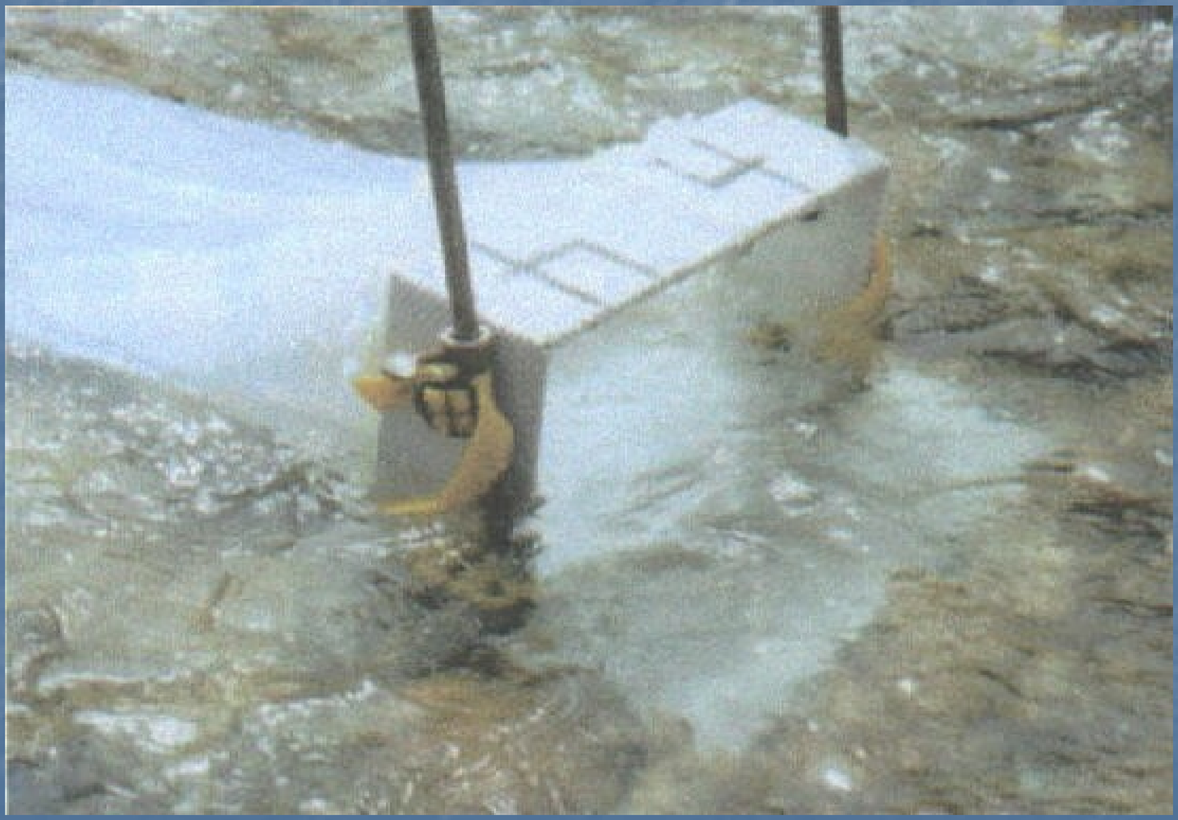
"Conclusions: The mechanics of sediment transport is so complex that it is extremely unlikely that a full understanding will ever be obtained" (p.695)

- Simons, D.B. and F. Senturk. 1992. Sediment Transport Technology. Water Resources Publications. 897 pp.

Depth-Integrated Suspended

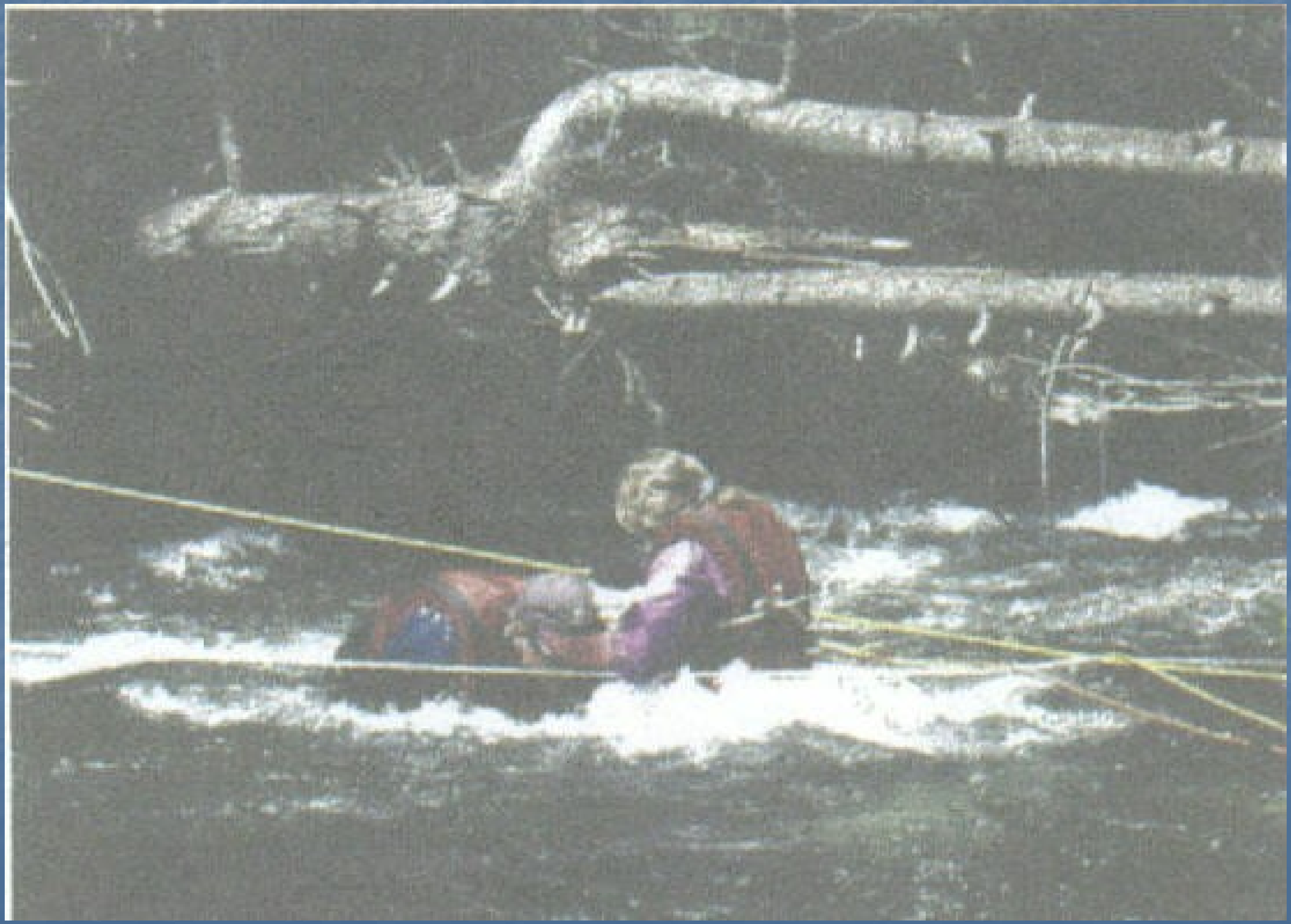
Helley-Smith Sampler

Bunte (2003) bedload net trap

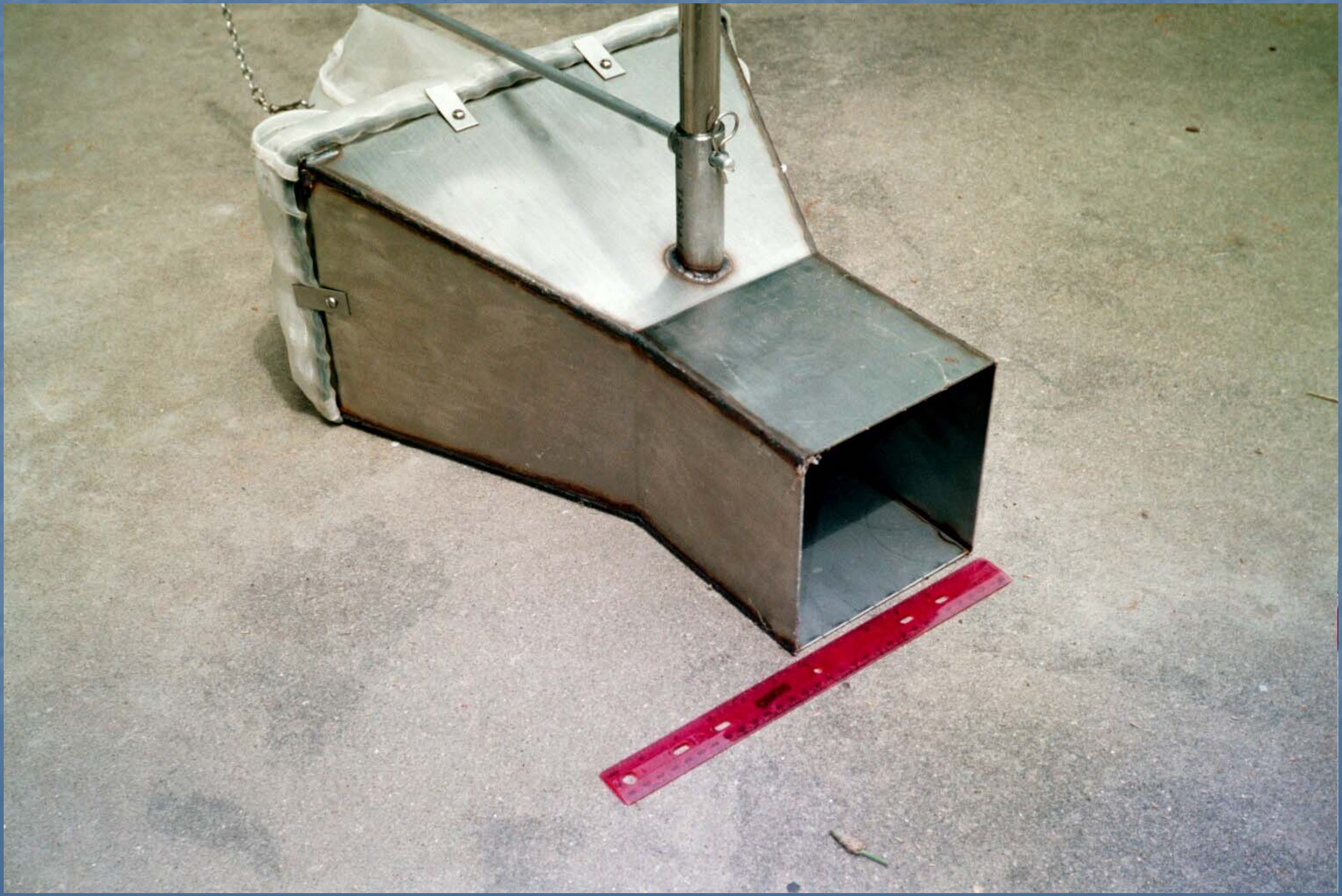


Bedload net samples (Bunte '03)

Retrieving bedload net samples



Helley-Smith Sampler



Other Issues in Bedload Sampling

- Particle sizes captured (and missed), re: sampler mouth opening; mesh size & location of nets used; operator
- Inclusion of suspended sediment, if cross-section of water column is sampled;
- Site limitations (e.g., if bridge &/or winch are required); resuspension from pits;
- Limited sample time (to clog or fill net);
- Cost; Safety; Portability; Ease of Use

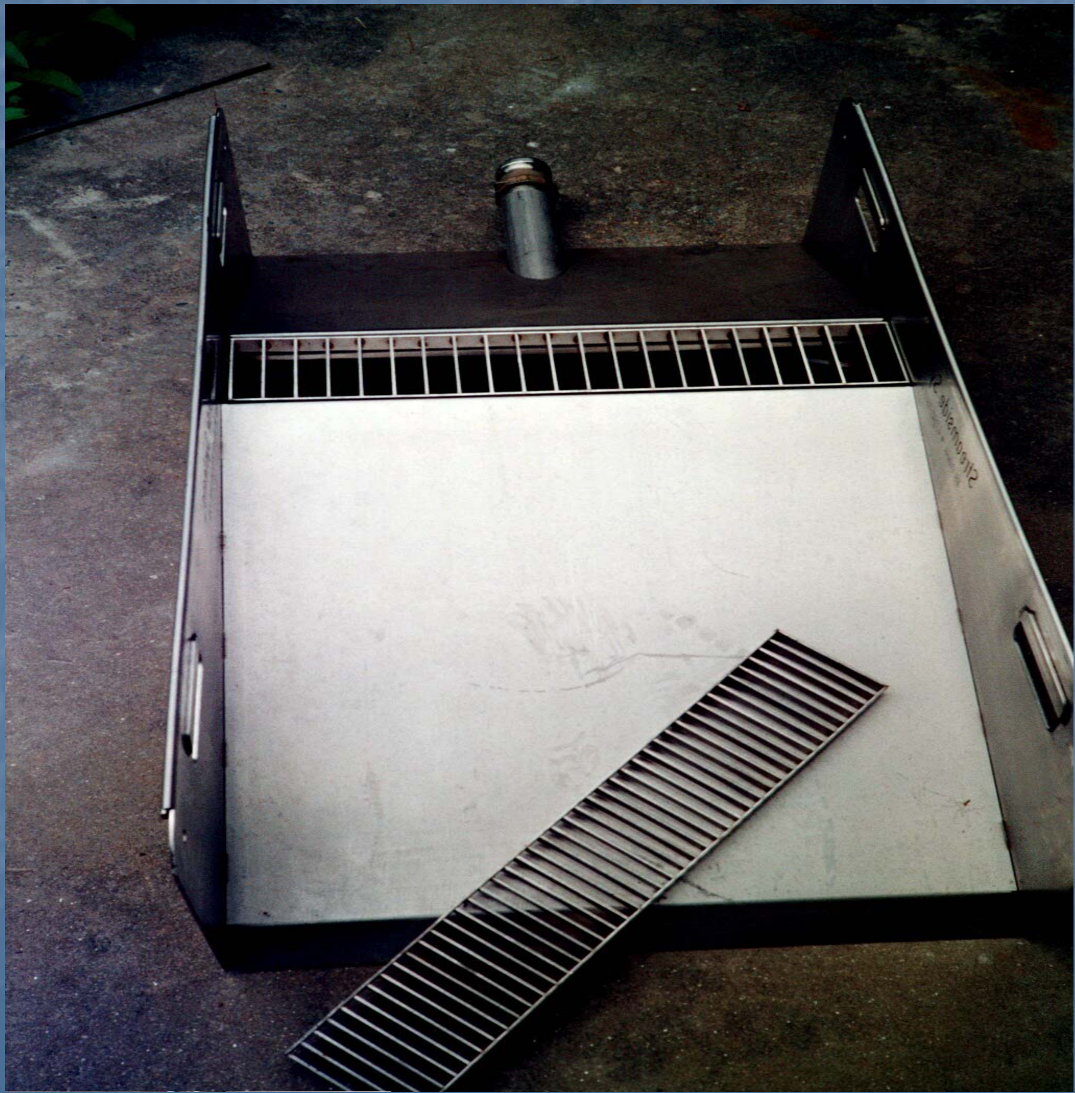
Streamside Systems Bedload

- Ramped collector on bottom of stream;
- Slotted screen(s) to collect targeted sizes of bottom sediments, as the stream delivers them
- Collected sediment may be pumped out (continuous or intermittent), or removed by siphon action; larger screens use one or more removable hoppers; minimize TSS inclusion;
- Variable sizes and capacities, scalable to any size stream; can target total bedload, long-term
- Portable (2-ft, 100lbs) to permanent (15-ft, 35 ton) linkable installations.


JUN 29 2004

Streamside Systems (small 3-hopper)

Streamside Systems (siphon)



Streamside Systems (underside)

Bedload Sample from 3-hopper

Streamside Systems (siphon)

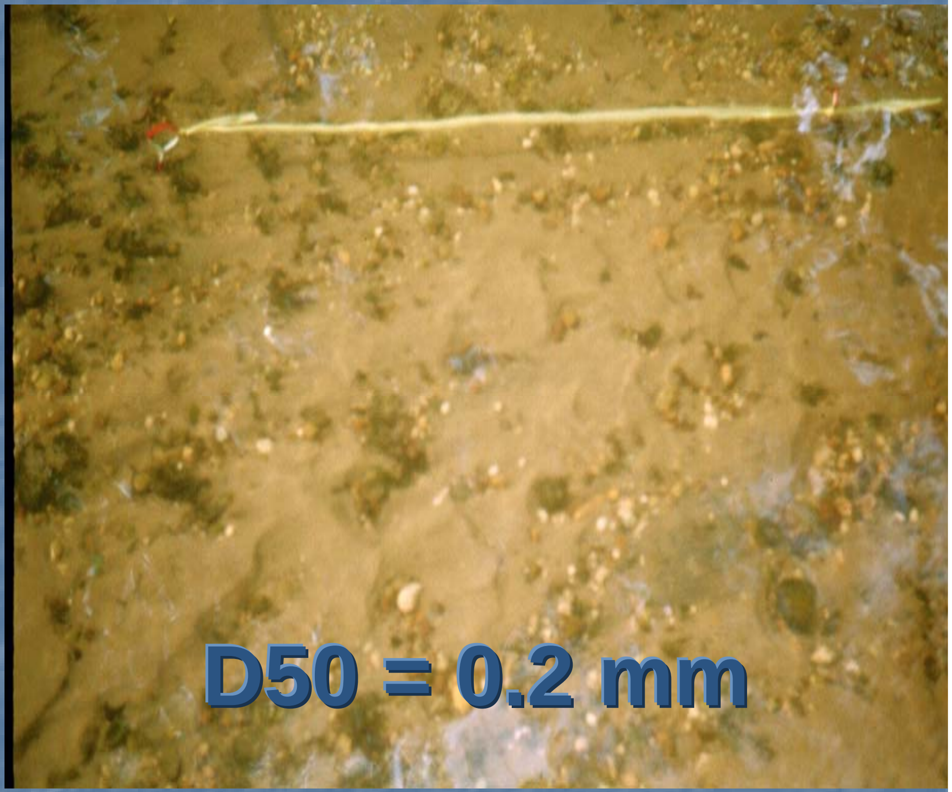
Streamside Bedload Advantages

- Increased Safety; Flexibility in site locations
- Reduced Variability; site-specific designs
- Ability to Target Total Bedload (from fines through boulders, across full channel)
- Continuous Monitoring (hours to months), with discrete sample availability and backflush
- Ability to Selectively Remove and Measure Bedload Fines (+restoration, +TMDL's)
- Avoid Suspended Sediments and Organic Load
- Unattended operation; no resuspension or loss

Types of bedload data required, determine monitoring gear used

- Hydrologist or geomorphologist commonly ignores the fines (e.g., 1-mm mesh Helley-Smith), and is more concerned with stream competence, D84, and Dmax
- Water supply managers may be more concerned with reservoir loading rates
- Biologists and water quality managers may focus more on the harmful impacts from fines
- MATCH YOUR BEDLOAD DATA TO YOUR NEEDS

Little Manistee River, MI



NCASI 1999: "…Small bag with 1 mm mesh captures more sediment than a large bag with 0.2 mm mesh, due to increased hydraulic efficiency"

“Excess Sediment”

- Re: hydrology, morphology, mechanical transport, modeling, channel stability
- Re: aggradation, reservoir sedimentation, flood risk, deltas, power generation losses
- Re: habitat, diversity, endangered species, fish spawning and survival, interstitial
- Re: regulatory agencies, TMDL’s, BMP’s, prevention –vs- restoration of sediment-impacted habitats

RESTORATION OPTIONS

Restoration Applications

Using Streamside Collectors to Provide Bedload Data

- Natural Channel Design (below instream construction activities)
- Selective removal of fines, for restoration of sediment-impacted habitats
- Reduction of pond and reservoir sedimentation
- Reintroduction of sediment below dams
- Prevention of sediment impacts below dam-removal projects, and municipal stormwater systems
- Selective monitoring of fines for source identification and development of TMDL's
- Cleanup impacting sediments below spills or failed BMP's

Snow Creek, Stokes Co, NC

- Natural Channel Design Project (July 2004)
- Use Streamside Systems sediment collectors at lower end of restoration reach, to prevent downstream sediment impacts
- Quantifying the material removed (before, during, and after) can document bedload transport, the proportion attributable to construction, and the quantity of fines prevented from impacting the stream.

Successful Long-term Examples:

- ~2 years continuous, northern Michigan trout stream, private club, selective removal of sands, winterized with insulated pumphouse and controller.
- ~2 years seasonal operation, Duck Creek, Juneau, Alaska, for selective removal of iron floc, to increase salmonid spawning survival and benthic diversity.

Koski, KV; Herricks, EE. 2004. Evaluation of a Method for Removing Iron Floc to Restore Anadromous Fish habitat in Duck Creek, Alaska. National Fish & Wildlife Foundation Final Report: Project # 1999-0239-000

- "The Streamside Systems device consisted of a 48" X 48" Series II Contractor Collector ... 11-ga stainless ... 2" pipe" (p.2)
- "The Collector was installed in the stream in August 2002 and evaluations were conducted in the fall, 2002, and in summer-fall, 2003" (p.3)
- "The approach using the Streamside Systems Inc Collector worked well in collecting the iron floc and pumping it to the dewatering bags ..." (p.6)
- "The Collector had no problem in collecting the iron floc" (K Koski, personal communication, 7 July 2004).

Independent Performance Testing

- Mike Shaffer (NCSU): three streams at Balsam Mountain Preserve, Jackson County, NC. In Progress.
- Hydraulics Laboratory, Engineering Research Center, Colorado State University, Ft Collins, CO. Summer 2004. 24 tests under variety of substrates and velocities, to assess the efficiency of total bedload capture, and the efficiency of selective removal of fine sediments.


JUN 29 2004


JUN 29 2004


JUN 27 2004